Reflectometer Series:

R54, R60 & R140

Vector Network Analyzers

KEY FEATURES

Patent: US 9,291,657 No test cable needed

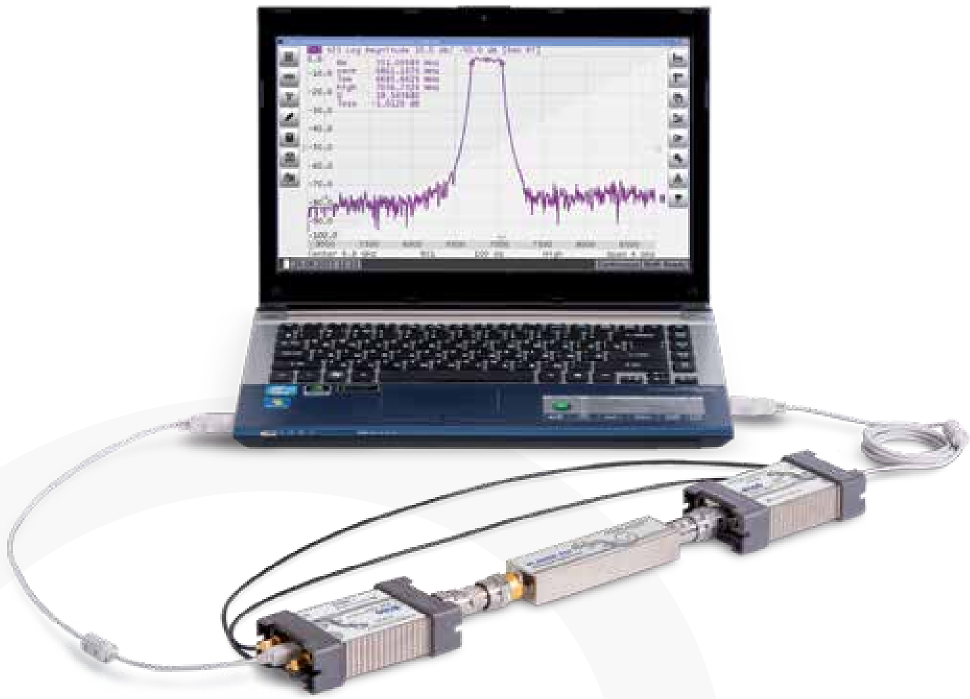
Frequency range: 1 MHz - 6.0 GHz or 85 MHz – 5.4 or 14 GHz

Measurement time per point: 100 or 200 µs min typ.

Number of measurement points: 2-100,001

Time domain with gating included standard

COPPER MOUNTAIN TECHNOLOGIES



Real Performance, Real Value.

Advanced

CMT analyzers take advantage of breakthrough advances in RF technology as well as the faster processing power, larger display, and more reliable performance of an external PC, while also simplifying maintenance of the analyzer.

Accurate

Our VNAs are made with high standards. Every instrument is lab-grade quality, with a wide dynamic range, low noise floor, high resolution sweep, and a variety of other advanced features. The metrology of R54, R60 and R140 deliver real measurement accuracy and reliability.

Cost Effective

CMT VNAs are flexible, easy to maintain, and are well-suited for lab, production, field, and secure testing environments. With every bit of performance of traditional analyzers, but at a fraction of the cost, now every engineer and technician can have a highly accurate VNA.

R54, R60 and R140 are USB vector reflectometers that operate in the frequency range from 1 MHz to 6.0 GHz or 85 MHz to 5.4 or 14 GHz. They are designed for use in the process of development, production, and field testing of various electronic devices in multiple environments, includeing operation as a component of an automated system.

The reflectometers connect directly to the DUT without the use of a test cable, so there is higher calibration stability in the test setup and the cost of the accessory replacement is significantly decreased. The device works with software on an external PC and is powered and operated by a USB interface.

These reflectometers ultra compact dimensions make them unique. At just 8.8 to 12.3 oz, they are easily transported between workstations or used in applications requiring mobility. R54, R60 and R140 present an excellent value solution for engineers and technicians: while they perform with the accuracy of a benchtop unit, they are equally well suited to field use or mass production environments.

Applications

Antenna testing

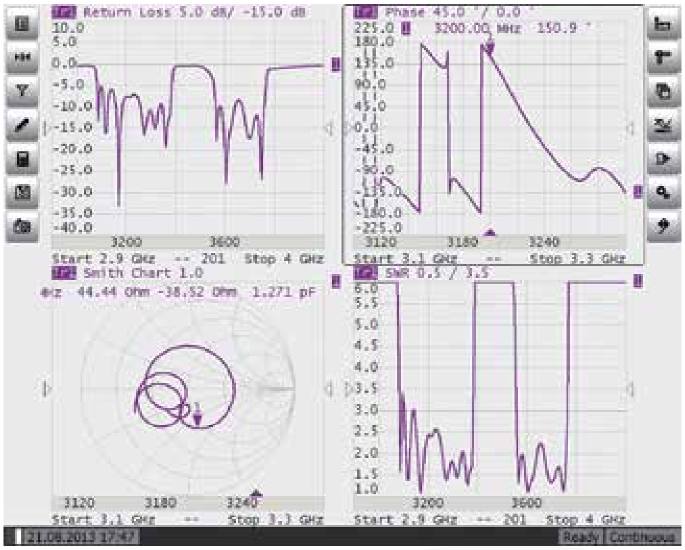
Reflectometers easily fit into many field test applications. They can be used with a ruggedized laptop to perform critical measurements in the field, such as antenna feeder systems. Because no test cable is needed, calibration stability is higher in the test setup and the cost of accessory replacement is significantly decreased.

Applications

Materials Test

Reflectometers allow the user perform measurement of material properties, such as dielectric constant and dielectric loss tangent. Its compact size and lack of test cables allowed SPEAG to use a reflectometer with a probe to perform materials testing.

Measurement Capabilities



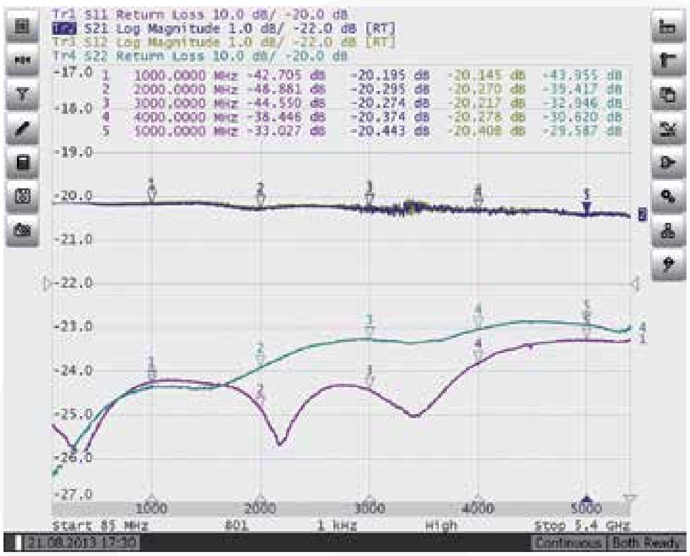
Measured parameters

S_{11}, cable loss

S_{11}, $|S_{21}|$, $|S_{12}|$, S_{22} - using two Reflectometers.

Number of measurement channels

Up to 4 independent logical channels. Each logical channel is represented on the screen as an individual channel window. A logical channel is defined by such stimulus signal settings as frequency range, number of test points, etc.

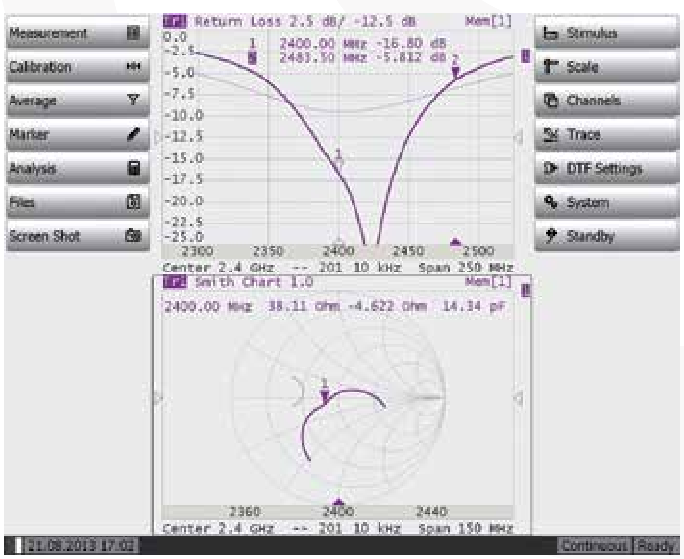


Data traces

Up to 4 data traces can be displayed in each channel window. A data trace represents one parameter of the DUT such as magnitude and phase of S_{11}, DTF, cable loss.

Memory traces

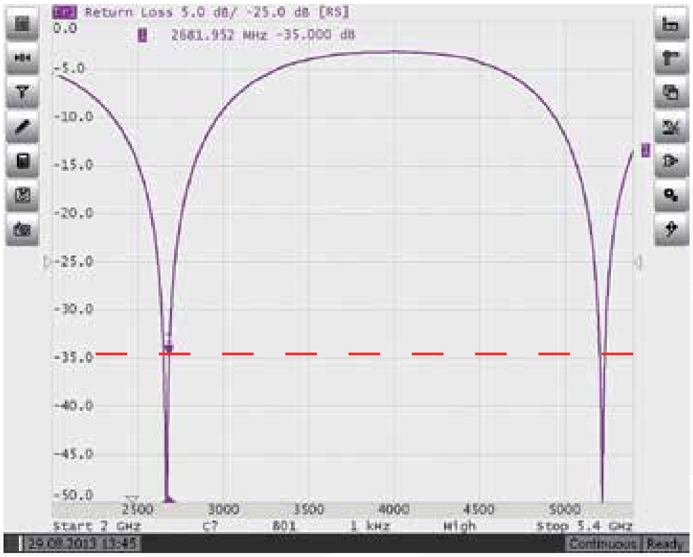
Each of the 4 data traces can be saved into memory for further comparison with the current values.



Data display formats

SWR, Return loss, Cable loss, Phase, Expand phase, Smith chart diagram, DTF SWR, DTF return loss, Group delay, Lin Magnitude.

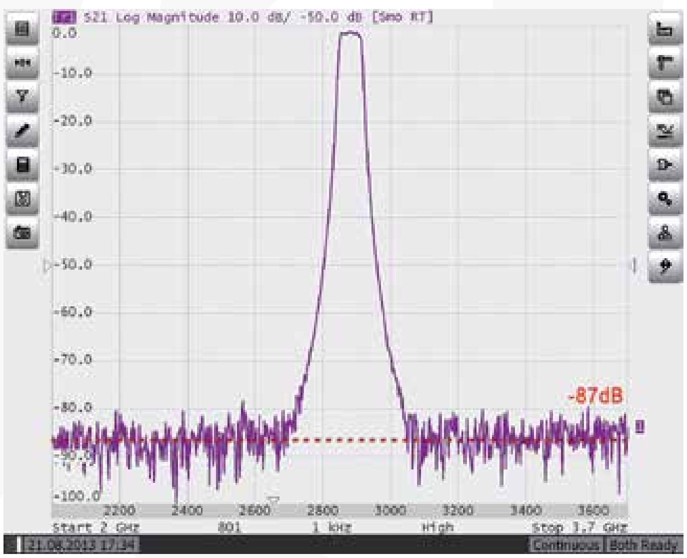
Measurement Range



R54 and R60 can measure return loss up to 35 dB in their entire frequency range. R140 can measure return loss up to 35 dB from 85 MHz to 4.8 GHz and 25 dB from 4.8 GHz to 14 GHz. R140, which is a specification typical of benchtop instrumentation.

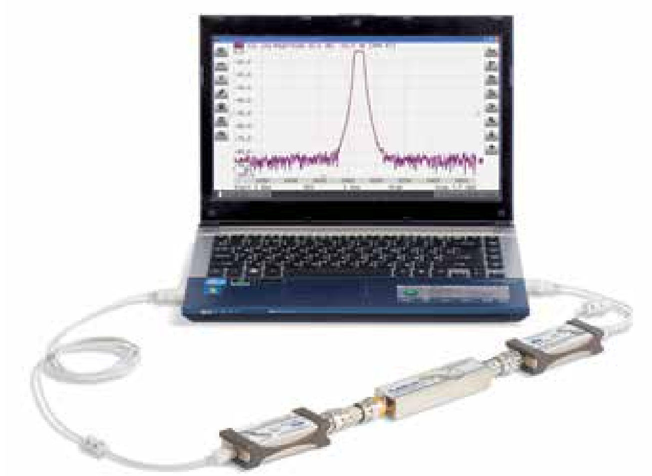
Pictured: R54 testing in the entire frequency range of 85 MHz to 5.4 GHz, the return loss is shown at 35 dB

Dynamic Range

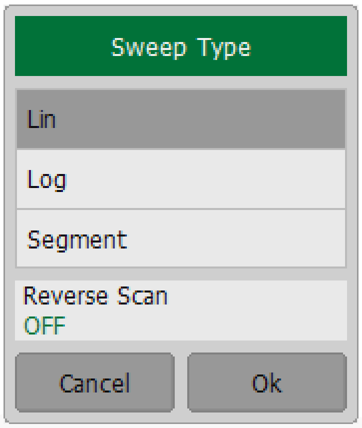


Typical dynamic range of the $|S_{21}|$ and $|S_{12}|$ measurements using two reflectometers across the entire frequency range at 100 Hz IF bandwidth for R54 is 97 dB, typ. and for R60 is 109 dB. typ. The dynamic range for R140 at 100 Hz IF bandwidth from 85 MHz to 4.8 GHz is 107 dB typ. and from 4.8 GHz to 14 GHz is 74 dB typ.

Pictured: R54 at 87 dB across the entire frequency range (at 1 kHz IF bandwidth)



Sweep Features



Sweep type
Linear frequency sweep, logarithmic frequency sweep, and segment frequency sweep.

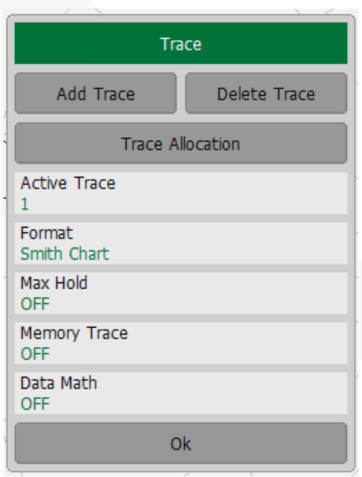
Measured points per sweep
Set by the user from 2 to 100,001.

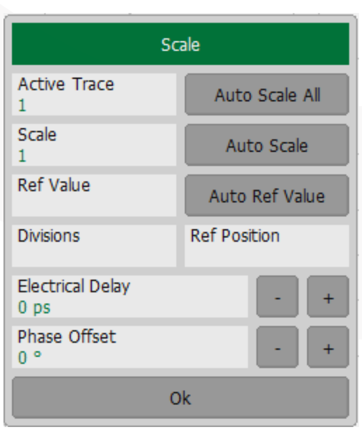
Segment sweep features
A frequency sweep within several independent user-defined segments. Frequency range, number of sweep points and IF bandwidth should be set for each segment.

Output Power
Min: -35 dBm depending on model
Max: +5 dBm depending on model

Sweep trigger
Trigger modes: continuous, single, or hold.
Trigger sources: internal, bus.

Trace Functions





Trace display
Data trace, memory trace, or simultaneous indication of data and memory traces.

Trace math
Data trace modification by math operations: addition, subtraction, multiplication or division of measured complex values and memory data.

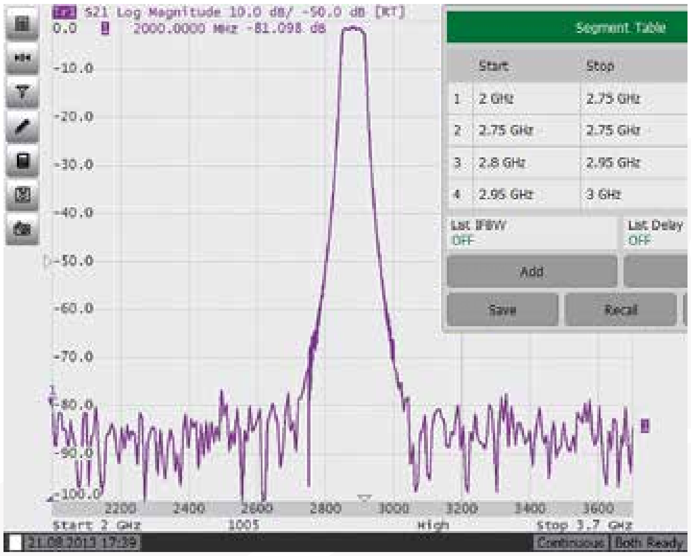
S-parameters display
The program allows to load into data memory Touchstone file(*.s1p and *.s2p).

Autoscaling
Automatic selection of scale division and reference level value to have the trace most effectively displayed.

Electrical delay
Calibration plane moving to compensate for the delay in the test setup. Compensation for electrical delay in a DUT during measurements of deviation from linear phase.

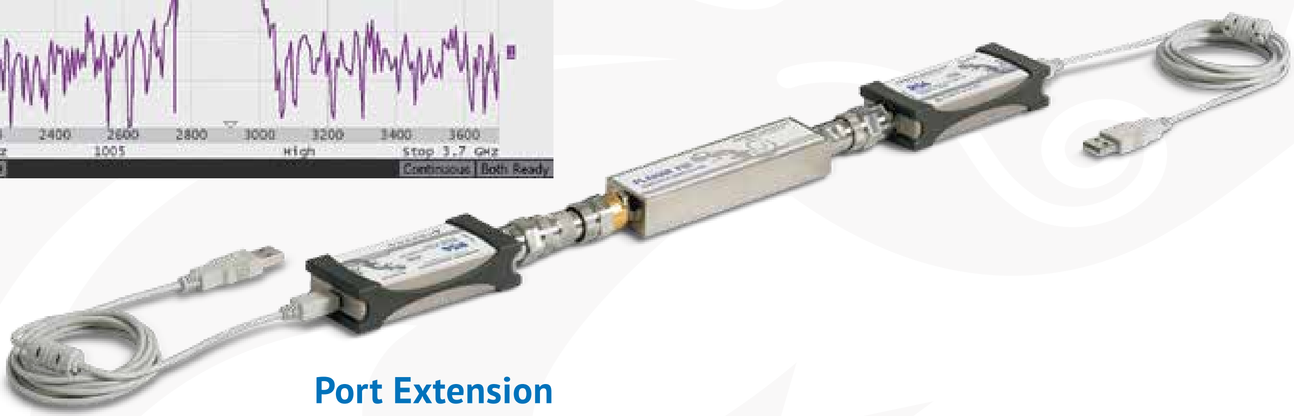
Phase offset
Phase offset is defined in degrees.

Frequency Scan Segmentation

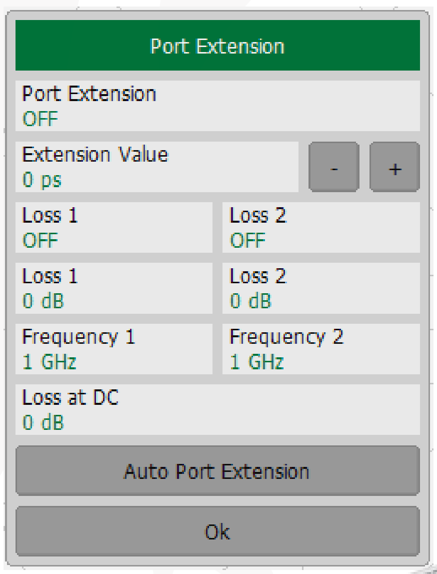


Reflectometers have a large frequency range with the option of frequency scan segmentation. This allows the user an opportunity to use the reflectometer, for example, to realize the maximum dynamic range while maintaining high measurement speed.

Pictured: Two R54s are shown with a demo filter. Users can measure $|S_{21}|$ and $|S_{12}|$ of the DUT using two reflectometers connected to the same USB hub.



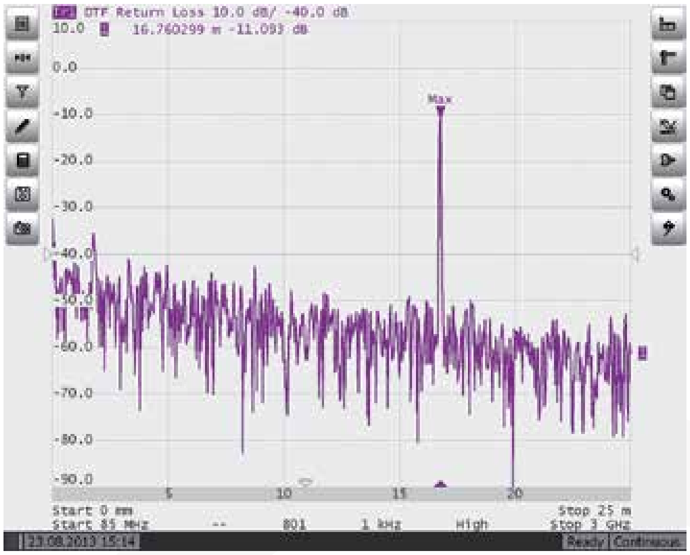
Port Extension



Port Extension is a feature that allows for moving the calibration reference plane of the port by specifying the electrical delay to the new reference plane position. Additionally, it is possible to account for loss in the extended port.

Automatic Port Extension is a feature that allows for automatic calculation of the electrical delay of the extended port and its loss by attaching an Open and/or a Short calibration standard at the new calibration reference plane position.

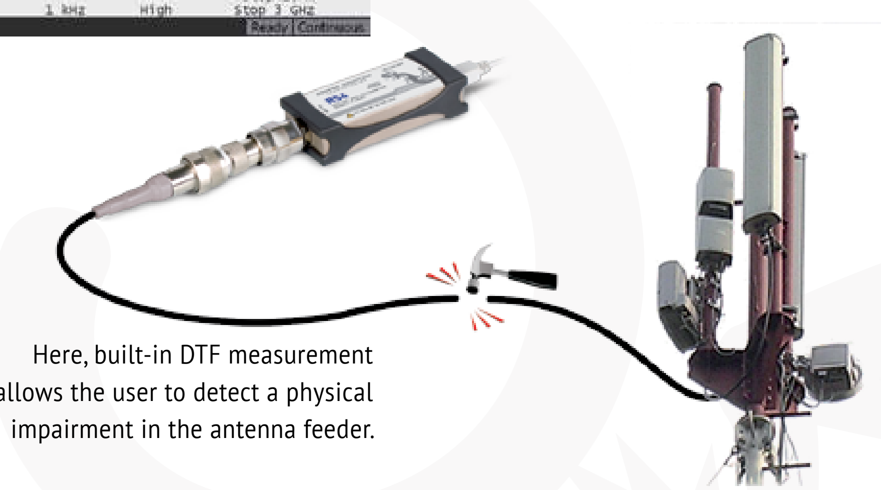
Time Domain Measurements



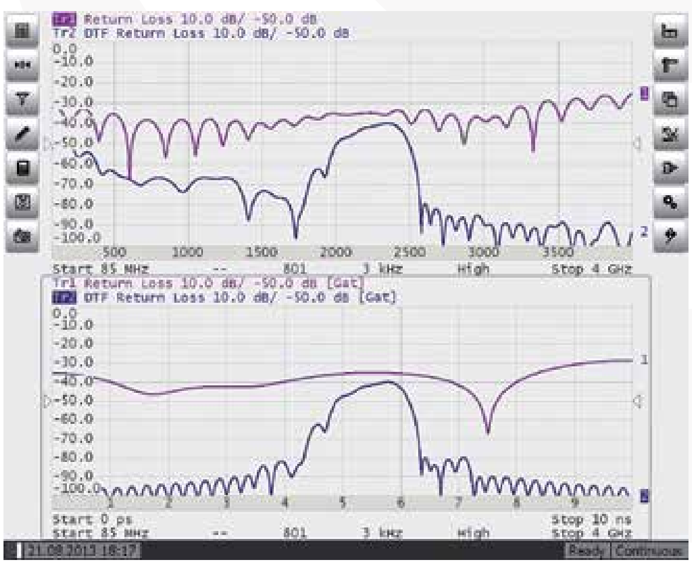
Distance to Fault (DTF)

DTF mode is enabled by selecting either the DTF SWR or DTF return loss format. The instrument will automatically transform measured data from the frequency domain to time domain, and then to distance based on the velocity of propagation. DTF easily finds fault points in cables or connectors.

Distance resolution can be maximized by selecting a wide measurement frequency range. Likewise, the maximum measured distance is proportional to the number of stimulus points.



Here, built-in DTF measurement allows the user to detect a physical impairment in the antenna feeder.

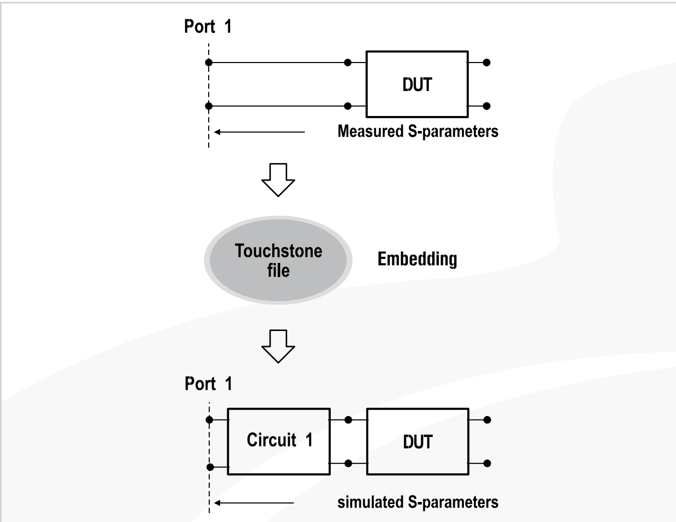


Gating

This function mathematically removes unwanted responses in the time domain, which allows the user to obtain frequency response without influence from the fixture elements. The function applies reverse transformation back to frequency domain after cutting out the user-defined span in time domain.

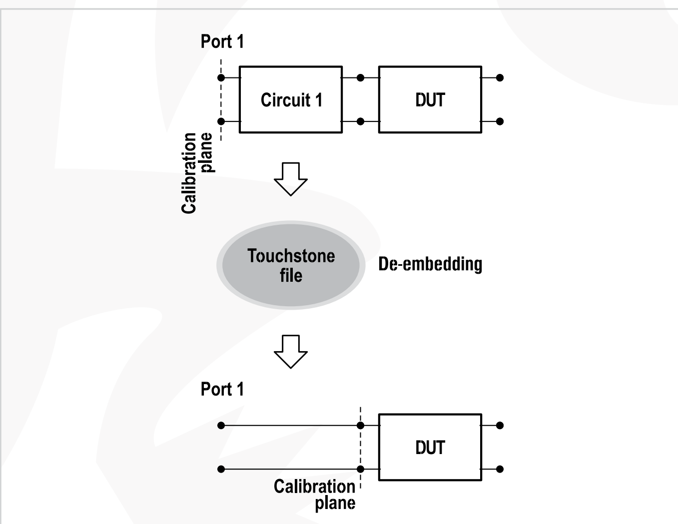
Gating filter types: bandpass or notch. For a better tradeoff between gate resolution and level of spurious sidelobes the following filter shapes are available: maximum, wide, normal and minimum.

Embedding



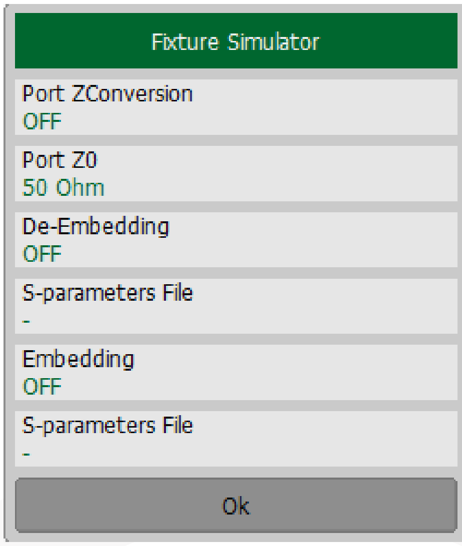
This function allows the user to mathematically simulate the DUT parameters after virtual integration of a fixture circuit between the calibration plane and the DUT. This circuit can be described by an S-parameter matrix in a Touchstone file.

De-Embedding



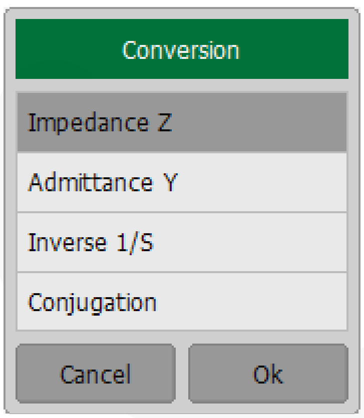
The function allows to mathematically exclude from the measurement result the effect of the fixture circuit connected between the calibration plane and the DUT. This circuit should be described by an S-parameter matrix in a Touchstone file.

Port Impedance Conversion



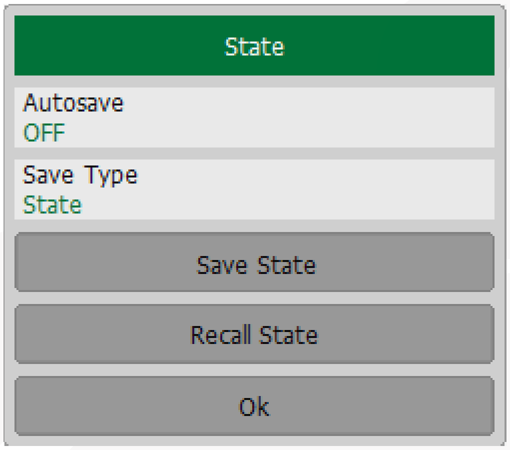
This is the function converts the S-parameters measured at 50 port into values, which could be determined if measured at a test port with arbitrary impedance.

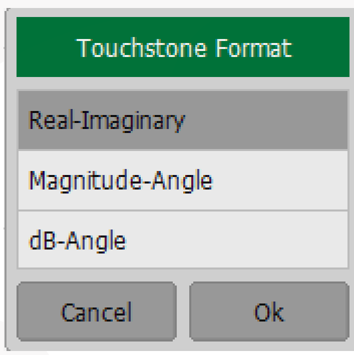
S-Parameter Conversion



The function allows conversion of the measured S-parameters to the following parameters: reflection impedance and admittance, inverse S-parameters and conjugation.

Data Output





Analyzer State

All state, calibration and measurement data can be saved to an Analyzer state file on the hard disk and later uploaded back into the software program. The following four types of saving are available: State, State & Cal.

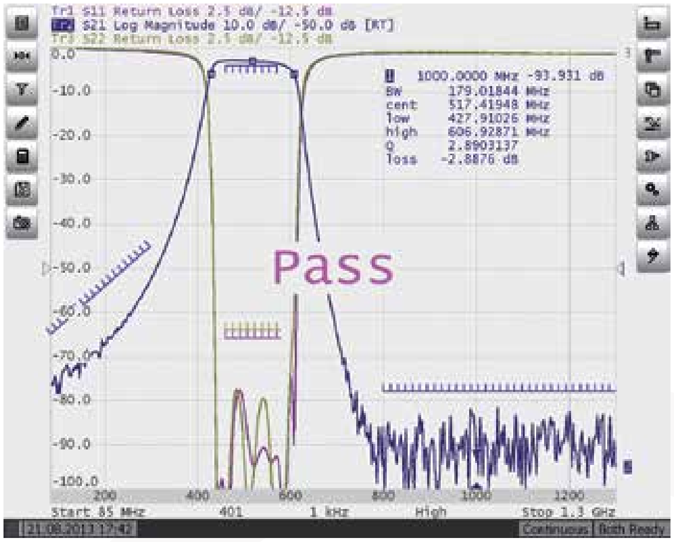
Trace Data CSV File

The VNA allows the user to save an individual trace data as a CSV file (comma separated values). The active trace stimulus and response values in the current format are saved to *.CSV file. Only one trace data are saved to the file.

Trace Data Touchstone File

R54, R60 and R140 allow the user to save S-parameters to a Touchstone file. The Touchstone file contains the frequency values and S-parameters. The files of this format are typical for most of circuit simulator programs. S_{11} parameters are saves using *.s1p files.
Only one (active) trace data are saved to the file.

Limit Testing



Setting Pass-Fail Tests

The limit test is a function of automatic pass/fail judgment for the trace of the measurement result. The judgment is based on the comparison of the trace to the limit line set by the user.

The limit line can consist of one or several segments. Each segment checks the measurement value for failing whether upper or lower limit. The limit line segment is defined by specifying the coordinates of the beginning (X0, Y0) and the end (X1, Y1) of the segment, and type of the limit. The MAX or MIN limit types check if the trace falls outside of the upper or lower limit, respectively.

Measurement Automation

COM/DCOM compatible

Reflectometer software is COM/DCOM compatible allowing the unit to be used as a part of measuring stands and different special applications. COM/DCOM automation is used for remote control and data exchange with the user software.

The reflectometer program runs as a COM/DCOM server, while the user program runs as COM/DCOM client. The COM client runs on the VNA PC, and the DCOM client runs on a separate PC connected via LAN.

LabView compatible

The device and its software are fully compatible with LabView applications, for ultimate flexibility in user-generated programming and automation.

Accuracy Enhancement

Calibration
Calibration of a test setup (which includes the VNA, cables, and adapters) significantly increases the accuracy of measurements. Calibration allows for correction of the errors caused by imperfections in the measurement system: system directivity, source match and tracking.

Calibration methods
The following calibration methods of various sophistication and accuracy enhancement level are available:

- reflection normalization
- transmission normalization (when using two reflectometers)
- full one-port calibration

Reflection and transmission normalization
This is the simplest calibration method; however, it provides reasonably low accuracy compared to other methods.

Full one-port calibration
Method of calibration performed for one-port reflection measurements. It ensures high accuracy.

Mechanical Calibration Kits
The user can select one of the predefined calibration kits of various manufacturers or define a new calibration kit.

Electronic Calibration Modules
Electronic, or automatic, calibration modules offered by CMT make calibration faster and easier than traditional mechanical calibration.

Defining of calibration standards
Different methods of calibration standard defining are available: standard definition by polynomial model standard definition by data (S-parameters)

Error correction interpolation
When the user changes any settings such as the start/stop frequencies or the number of sweep points, compared to the settings at the moment of calibration, interpolation or extrapolation of the calibration coefficients will be applied.

TECHNICAL SPECIFICATIONS[1]

Measurement Range

	R54	R60	R140	
Impedance	50 Ω	50 Ω	50 Ω	
Test port connector	N-type male	N-type male	N-type male	
Number of test ports	1	1	1	
Frequency Range	85 MHz to 5.4 GHz[2]	1 MHz to 6 GHz	85 MHz to 14 GHz	
Full CW Frequency	±5x10^{-6}	±2.5x10^{-6}	±2.5x10^{-6}	
Frequency Setting Resolution	***85 MHz to 5.4 GHz***	***1 MHz to 6.0 GHz***	***85 MHz to 4.8 GHz***	***4.8 GHz to 14 GHz***
	10 Hz	20 Hz	10 Hz	25 Hz
Number of Measurement Points	2 to 100,001	2 to 100,001	2 to 100,001	
Measurement Bandwidths (with 1/1.5/2/3/5/7 steps)	10 Hz to 30 kHz (with 1/3 step)	10 Hz to 100 kHz (with 1/3 step)	10 Hz to 30 kHz (with 1/3 step)	
Cable loss measurement range	***85 MHz to 5.4 GHz***	***1 MHz to 6.0 GHz***	***85 MHz to 4.8 GHz***	***4.8 GHz to 14 GHz***
	35 dB	35 dB	35 dB	30 dB
Dynamic range of $\|S_{21}\|$ and $\|S_{12}\|$[3]	***85 MHz to 5.4 GHz***	***1 MHz to 6.0 GHz***	***85 MHz to 4.8 GHz***	***4.8 GHz to 14 GHz***
	IF bandwidth 100 Hz	IF bandwidth 100 Hz	IF bandwidth 100 Hz	
	97 dB typ.	109 dB, typ.	107 dB, typ.	74 dB, typ.

Measurement Accuracy

	R54	R60	R140	
Accuracy of reflection measurements[4] (magnitude/phase)	***85 MHz to 5.4 GHz***	***1 MHz to 6.0 GHz***	***85 MHz to 4.8 GHz***	***4.8 GHz to 14 GHz***
-15 dB to 0 dB	0.4 dB / 4°	0.4 dB / 3°	0.4 dB / 4°	1.0 dB / 7°
-25 dB to -15 dB	1.5 dB / 7°	1.0 dB / 6°	1.2 dB /8°	1.5 dB / 10°
-35 dB to -25 dB	4.0 dB / 22°	3.0 dB / 20°	4.0 dB / 22°	5.0 dB / 29°
Accuracy of transmission magnitude measurements				
-40 dB to 0 dB	1.0 dB	-	-	-
-50 dB to 0 dB	-	1.0 dB	1.0 dB	-
-25 dB to 0 dB	-	-	-	1.0 dB
Trace Stability				
Trace noise magnitude (high output power, IF bandwidth 1 kHz)	0.015 dB rms	0.005 dB rms	0.005 dB rms	0.050 dB rms
Temperature dependence (per one degree of temperature variation)	0.02 dB	0.015 dB	0.015 dB	0.030 dB

[1] All technical specifications subject to change without notice.

[2] All specification in the frequence range from 4.8 GHz to 5.4 GHz are typical.

[3] Measurement of $|S_{21}|$ and $|S_{12}|$ using two reflectometers, both being connected to the same USB hub, applies over the temperature range of 23°C ± 5°C after 30 minutes of warming-up, with less than 1°C deviation from the calibration temperature at high output power and IF bandwidth 100 Hz.

[4] Applies over the temperature range of 23°C ± 5°C after 30 minutes of warming-up, with less than 1°C deviation from the full one-port calibration temperature at high output power and IF bandwidth 100 Hz.

TECHNICAL SPECIFICATIONS

Effective System Data[4]

	R54	R60	R140	
	85 MHz to 5.4 GHz	*1 MHz to 6.0 GHz*	*85 MHz to 4.8 GHz*	*4.8 GHz to 14 GHz*
Effective directivity	45 dB	46 dB	45 dB	42 dB
Effective source match	37 dB	40 dB	37 dB	35 dB
Effective reflection tracking	0.10 dB	0.05 dB	0.10 dB	0.20 dB

Effective Factory Calibrated Data

	R54		R60		R140
Effective directivity	*85 MHz to 4.0 GHz*	*4.0 GHz to 5.4 GHz*	*1 MHz to 4.0 GHz*	*4.0 GHz to 6.0 GHz*	-
	36 dB	32 dB	36 dB	32 dB	-

Test Port

	R54	R60	R140	
Directivity (without system error correction)	18 dB	15 dB, 18 dB typ.	10 dB, 15 dB typ.	
Match (without system error correction)	18 dB	15 dB, 18 dB typ.	10 dB, 15 dB typ.	
Output power	*85 MHz to 5.4 GHz*	*1 MHz to 6.0 GHz*	*85 MHz to 4.8 GHz*	*4.8 GHz to 14 GHz*
High level	-10 dBm, typ.	-	0 dBm, typ.	-10 dBm, typ.
Low level	-30 dBm, typ.	-	-35 dBm, typ.	-
Power range	-	-35 to 0 dBm (-37 to +5 dBm typ.)	-	
Power resolution	-	0.25 dB, typ.	-	
Interference immunity	+17 dBm	+17 dBm	+17 dBm	
Damage level	+23 dBm	+23 dBm	+23 dBm	
Damage DC voltage	50 V	50 V	50 V	

Measurement Speed

	R54	R60	R140
Measurement time per point, min typ.	200 μs	100 μs	200 μs

[4] Applies over the temperature range of 23°C ± 5°C after 30 minutes of warming-up, with less than 1°C deviation from the full one-port calibration temperature at high output power and IF bandwidth 100 Hz.

General Data

	R54	R60	R140
External reference frequency	-	10 MHz	32 MHz
Input level	-	2 dBm ± 2 dB	2 dBm ± 2 dB
Input impedance at Ref input	-	50 Ω	50 Ω
Connector type	-	SMA, female	SMA, female
Output reference signal level at 50 Ω impedance Ref output	-	3 dBm ± 2 dB	3 dBm ± 2 dB
Ref connector type	-	SMA, female	SMA, female
External trigger	-	3.3 V CMOS, TLL compatible	3.3 V CMOS, TLL compatible
Pulse width	-	More than 1 μs	More than 1 μs
Input impedance at «Ext Trig»	-	At least 10 kΩ	At least 10 kΩ
Input connector type	-	SMA, female	SMA, female

Atmostpheric Tolerances

	R54	R60	R140
Operating temperature range	-10°C to +50°C	-10°C to +50°C	-10°C to +50°C
Storage temperature range	-40°C to +55 °C	-40°C to +55°C	-40°C to +55°C
Humidity	90% at 25°C	90% at 25°C	90% at 25°C
Atmospheric pressure	84 to 106.7 kPa	84 to 106.7 kPa	84 to 106.7 kPa

Calibration Frequency

	R54	R60	R140
Calibration interval	3 years	3 years	3 years

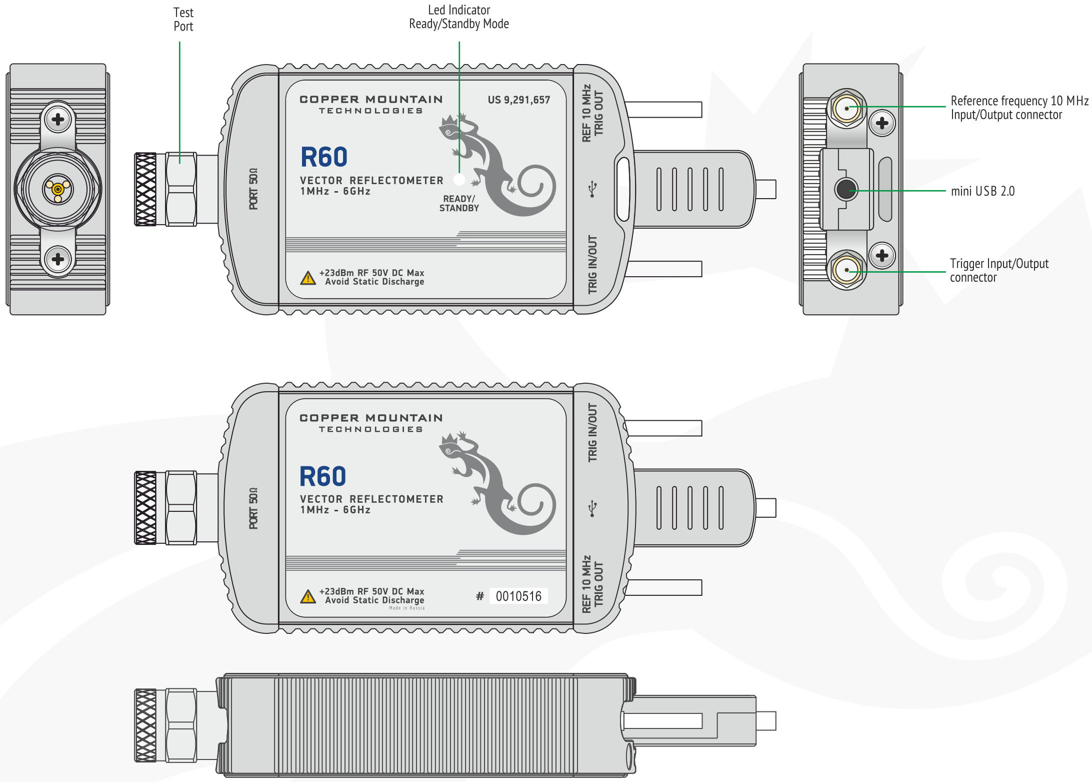
External PC System Requirements

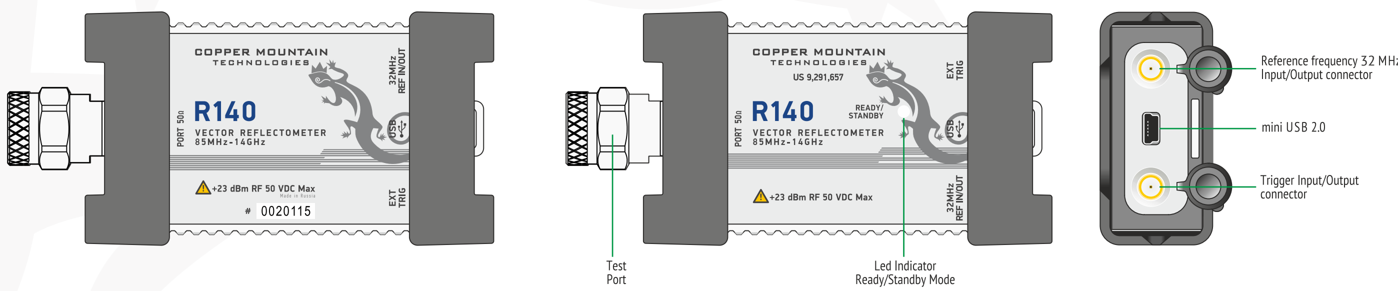
	R54	R60	R140
Operating system	Windows: XP, Vista, 7, 8, 10	Windows: XP, Vista, 7, 8, 10	Windows: XP, Vista, 7, 8, 10
CPU frequency	1 GHz	1 GHz	1 GHz
RAM	2 GB	2 GB	2 GB

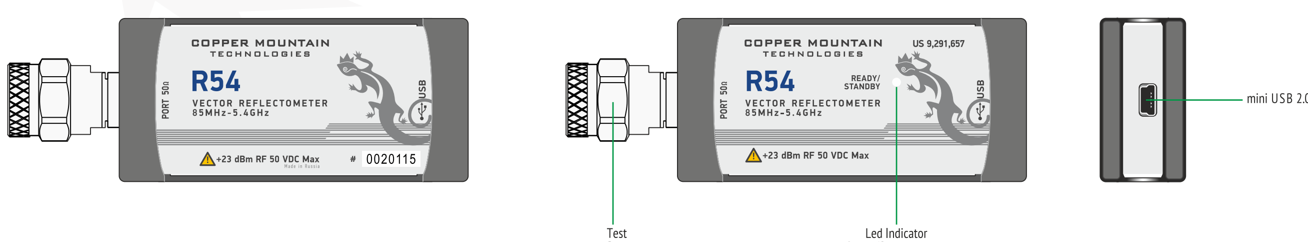
Connection to PC

	R54	R60	R140
Connector type	Mini USB B	Mini USB	Mini USB B
Interface	USB 2.0	USB 2.0	USB 2.0
Power consumption	2 W	3.5 W	3 W
Dimensions (L x W x H)	4.7 x 1.7 x 0.9 in	6.4 x 2.6 x 1.2in	4.5 x 2.0 x 0.9 in
Weight	8.8 oz	12.3 oz	10.6 oz

Front and Back Panels







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